more preferably 70 to 98%. Preferably, the support has a volumetric average pore size, as measured by BET, of 0.1 μm or greater, more preferably between 1 and 500 μm. Preferred forms of porous supports are foams and felts and these are preferably made of a thermally stable and conductive material, preferably a metal such as stainless steel or FeCrAlY alloy. These porous supports can be thin, such as between 0.1 and 1 mm. Foams are continuous structures with continuous walls defining pores throughout the structure. Felts are nonwoven fibers with interstitial spaces between fibers and includes tangled strands like steel wool. The porous supports may be stacked between a heat transfer wall and a sheet with through surface features. Alternatively, the porous supports may be etched, cut or otherwise have active surface feature grooves placed within the sheets. The sheets may be stacked with non-porous sheets that serve as walls to form an assembly. In this embodiment, the porosity of the active surface feature itself increases the number of sites for chemical reaction where the reactants may diffuse from the groove formed within the porous sheet to the internal and smaller pores present within the porous sheet. An active catalyst layer or layers may be disposed upon the porous sheet. The through surface features bring molecules via both advection and diffusion into the recessed grooves where they can continue to diffuse within the porous supports where a catalyst is disposed therein or thereon. As the molecules spend disproportionately more time in the features as the Reynolds time is increased, there is more time for the reactants to collide with and react with the catalyst surfaces. As the reactants spend time within the surface feature grooves and the porous catalyst layer they are not being convectively moved downstream with the bulk flow and thus away from the active catalyst.

[0159] A catalyst with a large pores (and including the alumina-supported catalytically active sites) preferably has a pore volume of 5 to 98%, more preferably 30 to 95% of the total porous material's volume. Preferably, at least 20% (more preferably at least 50%) of the material's pore volume is composed of pores in the size (diameter) range of 0.1 to 300 microns, more preferably 0.3 to 200 microns, and still more preferably 1 to 100 microns. Pore volume and pore size distribution are measured by mercury porisimetry (assuming cylindrical geometry of the pores) and nitrogen adsorption. As is known, mercury porisimetry and nitrogen adsorption are complementary techniques with mercury porisimetry being more accurate for measuring large pore sizes (larger than 30 nm) and nitrogen adsorption more accurate for small pores (less than 50 mm). A catalyst, such as a catalyst metal disposed on an oxide layer can be deposited on the large pore support.

[0160] In some embodiments, the height and width of a microchannel defines a cross-sectional area, and this cross-sectional area comprises a porous catalyst material and an open area, where a porous catalyst material occupies 5% to 99% of the cross-sectional area and where the open area occupies 5% to 99% of the cross-sectional area. In another alternative, catalyst can be provided as a coating (such as a washcoat) of material within a microchannel reaction channel or channels. The use of a flow-by catalyst configuration can create an advantageous capacity/pressure drop relationship. In a flow-by catalyst configuration, fluid preferably flows in a gap adjacent to a porous insert or past a wall coating of catalyst that contacts the microchannel wall (preferably the microchannel wall that contacts the catalyst is in direct thermal contact with a heat exchanger (preferably a microchannel heat exchanger), and in some embodiments a heat exchange stream contacts the opposite side of the wall that contacts the catalyst).

[0161] In some embodiments, a microchannel contains a porous flow-by catalyst that has a thickness (>25 microns) greater than a wall washcoat (<25 microns). In some embodiments, the thickness of the porous flowby catalyst may exceed 25 microns as can the thickness of the catalyst washcoat. In all cases it is preferred for the washcoat thickness to be less than the thickness of the flow-by catalyst structure. A porous catalyst may have surface features (preferably recessed features) that perturb both the bulk flow path in the open flow channel to reduce external mass transport resistance and promote advection within the surface features which aids bringing fresh reactant to the porous catalyst structure and removing product. The recessed surface features may be recessed all the way through or part of the way through the thickness of the thick porous catalyst structure. The porous catalyst may be any length; for example, a continuous porous catalyst (with surface features) or discontinuous porous catalyst (separated by surface features) may extend over a length of at least 1 cm, 3 cm or more.

[0162] Surface features could be formed in a large pore catalyst such as a catalyst foam or catalyst felt. A structured surface could be provided by inserting, into a microchannel, a catalyst insert having surface features. The insert could be formed of a large pore catalyst (such as a foam or felt) or by inserting a surface-featured metal support followed by coating a catalyst onto the surface of the support.

[0163] Washcoats are coatings that are applied to a channel wall by exposing a channel wall to a liquid based coating composition. The coating composition may contain a suspension of particles (typically a metal oxide or mixture of metal oxide and metal particles) or a sol. A catalyst coating that had been formed by washcoating may be called a washcoat.

[0164] A microchannel appratus may also contain multiple sections of active surface features along the length of the reactor. A first section may be used to imrove heat transfer while a second section may be used for a chemical reaction. Alternatively, there may be two or more sections within a unit operation where either reactions are mass exchange such as a separation are occuring. It may be advantageous to have two or more chemical reactions in series in distinct surface feature sections. In one embodiment two distinct reactions may be preferred for the case of a series reaction or to add a new reactant to continue the reaction or to just continue the reaction with a new heat transfer fluid or continue a reaction while controlling or tailoring the wall temperature between or in the surface feature section or otherwise control the mechanical strain of the metal. Another motivation to have two or more active surface feature sections in series in a microchannel apparatus may make use of a channel that contains a bend or a U-flow where the flow travels essentially in one direction before bending and traveling back down a second channel. An active surface feature section may be made in both the forward and back path, especially useful in a catalytic combustion application where low emissions are desirable.

Capillary Features in Microchannel Walls

[0165] Surface features can also act as capillary features that are useful to enable selective retention of a liquid on or